Orbital Debris Remediation by Hypervelocity Dust Impact*

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A recent NRC report [1] concerning orbital debris hazards has concluded that we are at the tipping point for collisional cascade to exponential growth of small orbital debris. A NASA study [2] suggests active removal of small-scale (1mm – cm) 'mission-ending' orbital debris in order to maintain access to near-earth space environment. A small 50 gm debris colliding with a space asset at 15 km/s can deliver the energy equivalent of 1 kg of TNT. At NRL we are developing concepts for small debris elimination through deployment of micron scale dust to artificially enhance the drag on the debris [3]. The key physics that makes this technique efficient is the possibility of huge momentum boost through hepervelocity dust/debris collision. Ballistic coefficients of 5 – 10 kg/m^2 represent small debris in a variety of sizes and shapes. For example, broken pieces of satellites (aluminum, density 2.7 gm/cc) with dimension 10 cm × 10 cm × 1.5 mm or 30 cm × 30 cm × 1.5 mm, etc., have a ballistic coefficient of ~ 5 kg/m^2. The dust density necessary to de-orbit such small debris is sufficiently low that it does not significantly affect the orbits of active satellites with much larger ballistic coefficients. By deploying micron scale dust in a narrow altitude band it is possible to artificially enhance drag on debris and force rapid reentry. The injected dust will also reenter the atmosphere leaving no permanent residue in space. Orbital and suborbital dust deployment concepts for actively removing debris that (i) has uniformly spread in a shell around the earth or (ii) remains localized over a small volume, as well as the system risks and their possible mitigation will be discussed.

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[1] Kessler D. et al, "Limiting Future Collision Risk to Spacecraft: An assessment of NASA's Meteriod and Orbital Debris Programs", Report of the Committee for the Assessment of NASA's Orbital Debris Programs, D. Kessler, Chair, National Academy of Sciences, 2011

[2] Liou, J.-C., Active Debris Removal and the Challenges for Environment Remediation, Paper 2011-r-32, 28th International Symposium on Space Technology and Science, Okinawa, Japan, June 5-12, 2011

[3] Ganguli, G., C. Crabtree, L. Rudakov, and S. Chappie, "A Concept For Elimination Of Small Orbital Debris", arXiv:1104, 2011